We Claim:

1.

A method for laser induced breakdown (LIB) of a material with a pulsed laser beam, the material being characterized by a relationship of fluence breakdown threshold versus laser pulse width that exhibits a rapid and distinct change in slope at a ~~predetermined~~ *characteristic* laser pulse width, said method comprising the steps of:

    a.   generating a beam of one or more laser pulses in which each pulse has a pulse width equal to or less than said ~~predetermined laser~~ *characteristic* pulse width; and

    b.   focusing said beam to a point at or beneath the surface of the material.

2.

The method according to claim 1 wherein the material is *a* metal, the pulse width is 10 to 10,000 femtoseconds, and the beam has an energy of 1 nanojoule to 1 microjoule.

3.

The method according to claim 1 wherein the laser beam defines a spot and has a lateral gaussian profile characterized in that fluence at or near the center of the beam spot is greater than the threshold fluence whereby the laser induced breakdown is ablation of an area within the spot.

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4.

The method according to claim 3 wherein the spot size is a diffraction limited spot size providing an ablation cavity having a diameter less than the fundamental wavelength size.

5.

The method according to claim 1 wherein the material is transparent to laser wavelength and the pulse width is 10 to 10,000 femtoseconds, the beam has an energy of 10 nanojoules to 1 millijoule.

6.

The method according to claim 1 wherein the material is biological tissue, the pulse width is 10 to 10,000 femtoseconds and the beam has an energy of 10 nanojoules to 1 millijoule.

7.

The method according to claim 1 wherein the predetermined pulse width is obtained by measuring the ablation (LIB) threshold of the material as a function of pulse width and determining where the ablation (LIB) threshold function no longer scales as the square root of pulse width.

8.

The method according to claim 1 wherein the laser beam has an energy in a range of 10 nanojoules to 1 millijoule.

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9.

    The method according to claim 1 wherein the
laser beam has a fluence in a range of 100 millijoules
per square centimeter to 100 joules per square
5   centimeter.

10.

    The method according to claim 1 wherein the
laser beam defines a spot in or on the material and the
10   LIB causes ablation of an area having a size smaller than
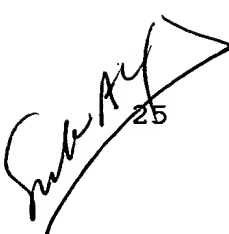the area of the spot.

11.

    The method according to claim 1 wherein the
15   laser beam has a wavelength in a range of 200 nanometers
to 2 microns.

12.

    The method according to claim 1 wherein the
20   pulse width is in a range of a few picoseconds to
femtoseconds.

13.

    The method according to claim 1 wherein the
25   breakdown includes chemical and physical changes.

14.

    The method according to claim 1 wherein the
breakdown includes chemical and physical breakdown.

15.

The method according to claim 1 wherein the breakdown includes disintegration.

16.

The method according to claim 1 wherein the breakdown includes ablation.

17.

The method according to claim 1 wherein the breakdown includes vaporization.

18.

The method according to claim 1 wherein the spot size is varied by flexible diaphragm to a range of 1 to 100 microns.

19.

The method according to claim 1 wherein a mask is placed in the path of the beam to block a portion of the beam to cause the beam to assume a desired geometric configuration.

20.

The method according to claim 1 wherein the laser operating mode is non-TEMoo.

21.

A method for laser induced breakdown of a material which comprises:

a. generating a beam of one or more laser pulses ~~comprising a sequence of pulses~~ in which each pulse has a pulse width equal to or less than a pulse width value corresponding to a change in slope of a curve of fluence breakdown threshold (F_{th}) as a function of laser pulse width (T), said change occurring at a point between first and second portions of said curve, said first portion spanning a range of relatively long pulse width where F_{th} varies with the square root of pulse width ($T^{\frac{1}{2}}$) and said second portion spanning a range of short pulse width relative to said first portion with a F_{th} versus T slope which differs from that of said first portion; and

b. focusing *said one or more pulses of* said beam to a point at or beneath the surface of the material.

22. The method according to claim 21 and further including:

a. identifying a pulse width start point;

b. focussing the laser beam initial start point at or beneath the surface of the material; and

c. scanning said beam along a predetermined path in a transverse direction.

23.

The method according to claim 21 and further
including:

  a. identifying a pulse width start point;

  b. focussing the laser beam initial start
point at or beneath the surface of the
material; and

  c. scanning said beam along a predetermined
path in a longitudinal direction in the
material to a depth smaller than the
Rayleigh range.

24.

The method according to claim 21 wherein the
breakdown includes chemical and physical changes.

25.

The method according to claim 21 wherein the
breakdown includes chemical and physical breakdown.

26.

The method according to claim 21 wherein the
breakdown includes disintegration.

27.

The method according to claim 21 wherein the
breakdown includes ablation.

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28. The method according to claim 21 wherein the
breakdown includes vaporization.

29. A method for laser induced breakdown of a
material which comprises:

    a.   determining, for a selected material, a
characteristic curve of fluence breakdown
threshold (F_{th}) as a function of laser
pulse width;

    b.   identifying a pulse width value on said
curve corresponding to a rapid and
distinct change in slope of said F_{th}
versus pulse width curve characteristic of
said material;

    c.   generating a beam of one or more laser
pulses, said ~~beam comprising a sequence of pulses~~ having a pulse width at or below
said pulse width value corresponding to
said distinct change in slope; and

    d.   focusing said one or more pulses of said beam to a point at or
beneath the surface of the material.

30. The method according to claim 29 and further
including:

    a.   identifying a pulse width start point;

b. focussing the laser beam initial start point at or beneath the surface of the material; and

c. scanning said beam along a predetermined path in a transverse direction.

31.

The method according to claim 29 and further including:

a. identifying a pulse width start point;

b. focussing the laser beam initial start point at or beneath the surface of the material; and

c. scanning said beam along a predetermined path in a longitudinal direction in the material to a depth smaller than the Rayleigh range.

32.

The method according to claim 29 wherein the breakdown includes chemical and physical changes.

33.

The method according to claim 29 wherein the breakdown includes chemical and physical breakdown.

34.

The method according to claim 29 wherein the breakdown includes disintegration.

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35.

The method according to claim 29 wherein the breakdown includes ablation.

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36.

The method according to claim 29 wherein the breakdown includes vaporization.

37.

The method according to any one of claims 1, 2, 5, 6, 21, and 29 wherein said beam is obtained by chirped-pulse amplification (CPA) means comprising means for generating a short optical pulse having a predetermined duration; means for stretching such optical pulse in time; means for amplifying such time-stretched optical pulse including solid state amplifying media; and means for recompressing such amplified pulse to ~~its~~ desired ~~original~~ duration. J.S., SKD. X.L. G.m. D.D PRL

38.

The method according to claim 1 wherein the spot size is varied within a range of 1 to 100 microns by changing the f number of the laser beam. JS. SKD. X.L G.m D.D. PRL

39.

The method according to claim 1 wherein the spot size is varied within a range of 1 to 100 microns by varying the target position.

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